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Studies on Insect-Proofness of Standard Powdered Milk
Containers, and Pertinent Supplementary Studies

By

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In cooperation with the Commodity Credit Corporation and the Commodity Stabilization Service, tests were conducted to determine the ability of the the larger cabinet beetle (Trogoderma versicolor) and the black carpet beetle (Attagenus piceus) to invade sealed fiberboard drums and wooden barrels containing dried powdered milk during storage. A secondary phase of these tests was to determine whether an infestation of the milk would result if insects were present in the container outside the inner liner and what could be expected if the milk itself was infested. While these tests were in progress, supplementary tests were conducted to determine the extent which insects may use empty containers and liners for harborage, and the insect-proofness of the $4\frac{1}{2}$ -pound cans of milk was also investigated. The above studies were started August 18, 1955 and terminated March 15, 1956.

Technique and Procedure

Tests on the insect-proofness of standard containers

The containers used in these studies were standard stock, fiberboard drums and wooden barrels commonly used by the dried milk industry. All containers, liners and sealers used were rigidly inspected to make certain that all test materials were insect-free. The dried milk used was obtained from a single plant and special precautions were taken to make certain that the milk, too, was insect-free.

The 36 drums and 12 barrels used in these studies were equally divided : one-half were placed in a test room infested with the larger cabinet beetle and the other half in a room infested with the black carpet beetle. In each of the two rooms the following series were set up using a randomized arrangement:

Fiberboard drums

Series A1: 3 drums, standard industry pack, with kraft (outer) and polyethylene (inner) liners, and kraft sealers, exposed to general infestation

Series A2: 3 drums, standard pack, also originally infested with 50 larvae each, in the powdered milk, and re-infested once with 50 additional larvae.

Series A3: 3 drums, standard pack, also infested originally with 50 larvae each between the kraft and polyethylene liners, and re-infested 3 times with 50 additional larvae each time.

Series A4: 3 drums, standard pack, also originally infested with 50 larvae each between the drum wall and the kraft liner, and re-infested twice with 50 additional larvae.

Series B: 3 drums, standard pack but with polyethylene liner double tied, exposed to general infestation.

Series C: 3 drums, no liners or sealers, exposed to general infestation.

Wooden barrels

Series D: 3 barrels, standard industry pack, with kraft (outer) and polyethylene (inner) liners, exposed to general infestation.

Series E: 3 barrels, no liners, exposed to general infestation.

The test rooms were in a warehouse in Madison, Wisconsin, and each contained approximately 250 square feet of floor space. The temperature and humidity were controlled as much as was possible under the existing conditions. The readings taken during the test period showed a temperature range between 70° and 90° F. in the black carpet beetle room, and 64° to 90° F. in the room having the larger cabinet beetle infestation. The relative humidity ranged from 30 to 86 percent in the former room, and from 24 to 92 percent in the latter. The conditions were favorable for insect development.

Each room was initially infested with 1200 larvae of the test insect involved. In addition, 1200 adults and 4100 larvae of the larger cabinet beetle, and 290 adults and 2,000 larvae of the black carpet beetle were added in the respective rooms during the 7-month exposure period. Powdered milk was scattered on the floors of the two test rooms to serve as food for the insects and to encourage the establishment of a natural infestation such as would exist under conditions of poor sanitation. Later the dry milk was removed to induce the insects to invade the test containers in search of food.

Drums in series A2, A3, and A4 were opened after 8, 12, 16, 22 and 26 weeks of exposure, and examined superficially for liner penetration and insect mortality. If mortality appeared to be high 50 additional larvae were introduced. Additional larvae of T. versicolor were added to series A3 drums on December 5, and February 13; and to series A2 drums on December 5. No additional black carpet beetle larvae were added to the drums.

Two kinds of inspections were made, superficial and detailed breakdown inspections. The superficial inspections were made weekly throughout the 7-month period, during which the number of insects observed on the exterior of the individual containers was recorded. The detailed breakdown inspection was made at the end of the 7-month exposure, at which time all containers were carefully examined, and the number of dead and live larvae, pupae, adults or cast skins recorded according to their location. The milk in each container was then sifted through 40- and 60-mesh screens in a laboratory-type mechanical sifter and the number of insects and cast skins recorded for the top 3 inches and the rest of the milk. Each liner and container was then thoroughly inspected for insects, cast skins, and penetrations.

Supplementary tests

Nine weeks after the exposure tests had been started, three empty drums were placed in each room to evaluate their significance as sources for insect harborage. Two of the drums were covered and one was left open. Three weeks later a kraft-paper-wrapped package of 5 new kraft and 5 polyethylene liners was also placed in each room. The empty drums and liners were thoroughly inspected for the presence of insect and cast skins at the end of the exposure period.

Three shipping cases, each containing six $4\frac{1}{2}$ -pound cans of powdered milk, as packed for the school lunch program, were placed in each room to observe whether or not insects could invade these containers. At the end of a 3-month exposure period the shipping cases were inspected and the milk in each of the cans was sifted to detect the presence of any insects.

Results

Tests on the insect-proofness of standard containers

During the weekly superficial inspections no larvae and only 2 adults were observed on the sides of any barrel or drum of milk stored in the room infested with T. versicolor. One live adult was observed on the covers of 2 drums and 3 barrels and 1 to 2 live larvae on the covers of 4 of the drums. On 1 drum cover a number of newly hatched larvae were noted. One or 2 dead adults could be found on the covers of most containers at some time during the exposure period.

Only 4 live adults and 1 live larva were observed on the sides of any barrel or drum stored in the room infested with the black carpet beetle. Single live adults were noted on the covers of 8 drums and 1 to 2 dead adults on the covers of 6 of the stored drums during the course of the test study. No adults were ever observed on the covers of any barrels. Single live larvae were found on the covers of 7 drums and 1 barrel. Three large larvae were noted on 1 drum cover and 8 newly hatched ones on another shortly after the initiation of the test and most of these larvae remained there throughout the entire exposure period.

During the superficial inspection of the pre-infested drums opened after the test had been in progress approximately 2 months, penetration of the kraft and polyethylene liners by the black carpet beetle larvae was observed. No penetration of the polyethylene or kraft liner by the larvae of T. versicolor was visible in any pre-infested drum opened while the test was in progress.

The results of the detailed breakdown inspection are summarized in table 1. The drums and barrels sealed according to approved commercial procedure (Series A1 and D) effectively protected the milk against insect infestation for the entire 7-month exposure period. Identical results were obtained with the drums in which the polyethylene liner was tied twice prior to sealing (Series B).

These tests showed that the standard sealed fiberboard containers (Series A1) are more insect-proof than the wooden barrels (Series B). No insects were found inside any of the drums, whereas some insects invaded the barrels and were found between the container wall and the outer liner as well as between the two liners. This point was further demonstrated in the results obtained with the drums and barrels (Series C and E) which were placed in the exposure rooms without liners or sealers. The infestation found in the barrels was considerably heavier than that in the drums.

Another important observation is that the sealer is very important in making the fiber drums insect-proof. The drums with the sealers (Series A1 and B) had no insects inside them at the end of the 7-month exposure period, whereas those without the sealers (Series C) had insects inside the containers.

The results obtained with the pre-infested drums (Series A2, A3, and A4) showed that both the kraft and polyethylene liners are subject to insect penetration by the black carpet beetle. The kraft liners were very susceptible but the polyethylene liners proved to be highly resistant to penetration by the larger cabinet beetle.

Another interesting observation made during the detailed inspection of both the drums and barrels was that when insects were present inside the containers between the container wall and the outside liner, or between the two liners, they were found below as well as above the level of the top surface of the milk.

Supplementary tests

In the supplementary tests conducted to determine the extent to which insects may use empty containers and liners for harborage, one larger cabinet beetle larva was observed in an empty open drum, while two black carpet beetle larvae were found in the upper rim, two on the interior of the bottom and 14 beneath the kraft paper lining on the bottom of the empty open drums.

No insects were found in the closed empty drums stored in these rooms.

Two larvae and one adult were observed inside one, and one larva inside another kraft liner stored in the black carpet beetle infestation room. From 3 to 5 larvae were observed on the exterior of the remaining kraft liners. One to two larvae were found on the exterior of three kraft liners and two larvae in the interior of one of the kraft liners stored in the larger cabinet beetle infestation room. No adults or larvae were found on or in any polyethylene liners stored in either room.

The inspection of the small containers showed that the insects are able to invade the shipping cases, for from 21 to 31 black carpet beetle larvae were found inside two of the cases and one to two larger cabinet beetle larvae were found in the set of cases exposed to that species. However, none of the $4\frac{1}{2}$ -pound cans of milk stored in either room contained any insect infestation.

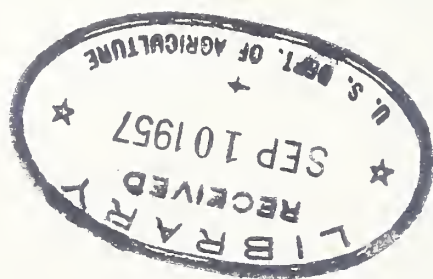
Discussion

In evaluating the results obtained in these tests, consideration should be given to the fact that the test materials were subjected to a very heavy insect infestation, one much more severe than would be encountered in the commercial processing, transportation and storage of dried milk. Under normal conditions, therefore, the amount of protection which can be expected from the types of packages and packaging materials tested would be as great or greater than shown in these tests.

Report submitted to Commodity Credit
Corporation by L. S. Henderson, Acting
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Table 1.--Locations of insects at the end of the 7 months exposure in relation to the source of infestation and the penetration of liners by insects

Source of infestation	Location of insects at end of 7 months exposure												Penetrations of liners by insects			
	Between container wall and outer liner						Between liners						In powdered milk			
	T. versicolor			Black carpet beetle			T. versicolor			Black carpet beetle			T. versicolor		Black carpet beetle	
	Insects	Cast skins	Number	Insects	Cast skins	Number	Insects	Cast skins	Number	Insects	Cast skins	Number	Insects	Cast skins	Number	Number
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
Outside of container only Series A1, standard pack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Series B, polyethylene liner double tied	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Series C, no liners.							15	21	0	0	0	0				
Series D, barrels, standard pack . .	42	6	44	31	21	5	0	0	0	0	0	0	10	0	0	0
Series E, barrels, no liners							42	145	21	0	0	0				
Between container wall and outer liner Series A4	96	109	59	27	23	15	2	2	0	0	0	0	31	102	1	0
Between liners Series A3	20	4	34	246	344	50	6	3	15	102	102	102	6	46	1	80
In powdered milk Series A2	0	0	0	1	1	50	96	331	68	10	10	10	0	30	1 (?)	139



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